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Synthesis of IB-01211, a Cyclic Peptide Containing 2,4- Concatenated Thia- and Oxazoles, via Hantzsch Macrocyclization

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General Data

Melting points (m. p.) were determined in a Büchi Melting Point B540 in open capillaries and are uncorrected. Reversed-phase analytical HPLC was performed on a Waters Alliance separation module 2695 using a Waters Xterra MS C₁₈ column (150 x 4.6 mm, 5 µm) and a Waters 996 PDA with a photodiode array detector (MeCN- 0.036 TFA : H₂O- 0.045 TFA). A Branson ultrasound bath was used to perform sonication. Polarimeter 241 Perkin Elmer was used. ¹H NMR and ¹³C NMR spectra were recorded on a Varian Mercury 400 MHz spectrometer. Multiplicity of the carbons was assigned with DEPT and gHSQC experiments, although usual abbreviations for off-resonance decoupling are used: (s) singlet, (d) doublet, (t) triplet, (q) quartet. The same abbreviations were used for the multiplicity of signals in ¹H-NMR and also: (m) multiplet, (dd) double doublet, (bs) broad singlet, (bd) broad doublet. Spectra were referenced to appropriate residual solvent peaks (CDCl₃). Mass spectra chemical ionisation (MS-CI) were measured on a Hewlett-Packard model 5890A for with ammonia (NH₃), MALDI-TOF and ES-MS analysis were performed in a PerSeptive Biosystems Voyager DE RP, using ACH matrix, and in a Waters alliance 2795 HPLC and 2487 UV-Vis detector and ZQ Electrospray mass detector, was run with MeCN (0.07% HCO₂H) and H₂O (0.1% HCO₂H). HRMS were performed on a Bruker Autoflex high resolution mass spectrometer by the Unidad de Espectrometría de Masas (Universidad de Santiago de Compostela).

GENERAL METHODS :

Peptide bond formation. *Example: Boc-D-allo-Ile-L-Val-OMe (1)* Boc-D-allo-Ile-OH (1 g, 4.32 mmol), EDC·HCl (911 mg, 4.75 mmol), HOBT (641 mg, 4.75 mmol), and DIEA (1.57 mL, 9.28 mmol)

were added to a solution of H-*L*-Val-OMe·HCl (797 mg, 4.75 mmol) in dry CH₂Cl₂ (50 mL) at 0 °C. The mixture was stirred at room temperature for 20 h. The organic solution was washed with 5% aqueous NaHCO₃ and aqueous NH₄Cl, dried and concentrated to give the title compound (1.43 g, 96%) as a white solid, m.p. 78-80 °C. ¹H NMR (CDCl₃, 400 MHz) δ 0.81-0.96 (m, 12H); 1.14-1.28 (m, 1H); 1.35-1.40 (m, 1H); 1.43 (s, 9H); 1.94-2.06 (m, 1H); 2.10-2.22 (m, 1H); 3.71 (s, 3H); 4.10-4.18 (m, 1H); 4.53 (dd, *J*= 4.4 Hz and 9.2 Hz, 1H); 4.96 (bs, 1H); 6.55 (bs, 1H). ¹³C NMR (CDCl₃, 400 MHz) δ 11.6 (q); 14.1 (q); 17.6 (q); 18.9 (q); 26.4 (t); 28.2 (q); 31.1 (d); 36.9 (d); 52.0 (q); 56.8 (d); 58.2 (d); 80.0 (s); 155.7 (s); 171.7 (s); 172.2 (s). MS (MALDI): *m/z* 367 (*M* + 23, 35), 255 (43), 246 (59), 245 (100). HRMS *m/z* calcd for C₁₇H₃₂N₂NaO₅ 367.2203 found 367.2214.

Hydrolysis of Me esters 2M LiOH (9 mmol) was added to a solution of methyl ester (3 mmol) in THF/H₂O/MeOH (50/6/0.2 mL), and the reaction mixture was stirred at room temperature for 1 h. After this time, 1M HCl was added until pH=3, and the solution was extracted with EtOAc. The organic solution was dried over MgSO₄ and concentrated to afford the acid as a white solid.

Deprotection with TFA: *Method A. Elimination of N-Boc and O-*t*Bu protecting groups.* 95% TFA (8 mL) was added to Boc-Ser(*t*Bu)-Ser-OMe (898 mg, 2.48 mmol), and the solution was stirred at room temperature for 5 h. After this time, the TFA was removed under reduced pressure. The crude material was used in the following reaction without purification.

Method B. Elimination of N-Boc protecting group. A solution of **1** (77.8 mg, 0.23 mmol) in TFA-CH₂Cl₂ (1:1, 1 mL) was stirred at room temperature for 1 h. The TFA was removed, and the crude material was used in the following reaction without purification.

DAST oxazoline formation: *Method A. With K₂CO₃ as base.* DAST (1.05 eq.) was added drop-wise to a solution of peptidyl-Ser (1 eq.) in CH₂Cl₂ (13 mL), cooled at -78 °C under N₂, and the reaction

mixture was stirred for 2 h at the same temperature. Anhydrous K_2CO_3 (2 eq.) was then added in one portion, and the reaction mixture was stirred for 15 min at $-78\text{ }^\circ\text{C}$, and then allowed to warm to room temperature for 20 min. The organic solution was poured into saturated aqueous $NaHCO_3$ and extracted with CH_2Cl_2 , dried over $MgSO_4$ and concentrated to give the oxazoline as an oil.

Method B. With pyridine as base. DAST (1.2 eq.) was added drop-wise to a cold ($-78\text{ }^\circ\text{C}$) solution of the PhSer-peptide (1 eq.) in THF (34 mL) under N_2 , and the reaction mixture was stirred for 2 h at the same temperature. Pyridine (3 eq.) was then added, and the mixture was stirred for 15 min at $-78\text{ }^\circ\text{C}$, and then allowed to warm to room temperature for 20 min. The organic solution was poured into saturated aqueous NH_4Cl and extracted with CH_2Cl_2 , dried and concentrated to give the phenyloxazoline as an oil, which was used without purification in the following reaction.

Oxidation of oxazoline DBU (2 eq.) was added to a cold ($-30\text{ }^\circ\text{C}$) solution of oxazoline (1 eq.) in CCl_4 -MeCN-Pyr (8.7:13:13 mL), and the solution was stirred for 48 h at room temperature. The solvents were removed *in vacuo* and the residue was purified by column chromatography on silica gel.

2'-(2-*tert*-Butoxy-1-*tert*-butoxycarbonylaminoethyl)-[2,4']bis-oxazolyl-4-carboxythioamide (2). Lawesson's reagent (102 mg, 0.25 mmol) was added to a solution of **8** (99 mg, 0.25 mmol) in THF (3.7 mL) and the reaction mixture was stirred under N_2 at $70\text{ }^\circ\text{C}$ for 8 h. The solvent was evaporated and the residue purified by chromatography. Elution with CH_2Cl_2 -EtOAc 9:1 gave **2** (73 mg, 73%) as an oil. 1H NMR ($CDCl_3$, 400 MHz) δ 1.10 (s, 9H); 1.46 (s, 9H); 3.74 (dd, $J = 4.4$ and 9.2 Hz, 1H); 3.79-3.91 (m, 1H); 5.10 (bs, 1H); 5.75 (bs, 1H); 8.20 (s, 1H); 8.40 (bs, 1H); 8.41 (s, 1H); 8.44 bs, 1H). ^{13}C NMR ($CDCl_3$, 400 MHz) δ 27.2 (q); 28.2 (q); 50.1 (d); 62.8 (t); 73.8 (s); 80.2 (s); 129.5 (s); 139.5 (d); 141.5 (s); 143.3 (d); 154.7 (s); 155.4 (s); 165.3 (s); 187.2 (s). MS (ES) m/z 411 ($M+1$, 100), 372 (52), 355 (62). HRMS m/z calcd. for $C_{18}H_{27}N_4O_5S$ 411.1702 found 411.1691.

Methyl 2'-(2-bromo-1,1-dimethoxyethyl)-5-phenyl-[2,4']bis-oxazolyl-4-carboxylate (3). Starting from **11** (56 mg, 0.122 mmol), following the general procedure using DAST, K₂CO₃ for cyclization and DBU, CCl₄ for oxidation, a residue was obtained, which was purified by column chromatography on silica gel. Elution with hexane/EtOAc (3:1) gave **3** (26.3 mg, 50%) as a yellow oil. ¹H NMR (CDCl₃, 400 MHz) δ 3.35 (s, 6H); 3.89 (s, 2H); 3.96 (s, 3H); 7.47-7.49 (m, 3H); 8.13-8.15 (m, 2H); 8.44 (s, 1H). ¹³C NMR (CDCl₃, 400 MHz) δ 31.78 (q); 50.3 (q); 52.4 (t); 99.33 (s); 126.4 (s); 127.6 (s); 128.4 (d); 128.7 (d); 130.3 (s); 130.6 (d); 140.2 (d); 152.8 (s); 155.7 (s); 161.2 (s); 162.3 (s). MS (CI) *m/z* 456 (MBr⁸¹ + NH₃, 54), 454 (MBr⁷⁹ + NH₃, 56), 439 (MBr⁸¹, 96), 437 (MBr⁷⁹, 100). HRMS *m/z* calcd. for C₁₈H₁₈BrN₂O₆ 437.0343 and 439.0327, found 437.0343 and 439.0344.

Boc-L-Ser(*t*Bu)-L-Ser-L-Ser-OMe (4). Deprotection of Boc-L-Ser(*t*Bu)-L-Ser-OMe (898 mg, 2.48 mmol) with 95% TFA and reaction with Boc-L-Ser(*t*Bu)-OH (680 mg, 2.6 mmol), following the general procedure for peptide preparation, gave **4** (890 mg, 80%) as an oil. ¹H NMR (CDCl₃, 400 MHz) δ 1.19 (s, 9H); 1.44 (s, 9H); 3.48-3.56 (m, 1H); 3.64-3.69 (m, 1H); 3.72-3.75 (m, 1H); 3.78 (s, 3H); 3.88-4.02 (m, 2H); 4.08-4.21 (m, 2H); 4.53-4.64 (m, 2H); 5.47 (bs, 1H); 7.47 (bs, 1H); 7.70 (bs, 1H). ¹³C NMR (CDCl₃, 400 MHz) δ 27.3 (q); 28.2 (q); 52.7 (q); 54.2 (d); 55.3 (d), 55.4 (d); 61.2 (t); 62.3 (t); 62.5 (t); 74.2 (s); 80.9 (s) 155.9 (s); 170.6 (s); 170.9 (s); 171.5 (s). MS (CI) *m/z* 450 (M+1, 100), 394 (41), 350 (14). HRMS *m/z* calcd. for C₁₉H₃₆N₃O₉ 450.2446, found 450.2441.

Boc-L-Ser(*t*Bu)-L,D-PheSer-OMe (5). Following the general procedure for peptides preparation starting from H-L,D-PhSer-OMe.HCl (120.5 mg, 0.52 mmol) and Boc-L-Ser(*t*Bu)-OH (131 mg, 0.50 mmol), **5** (218 mg, quantitative) was obtained as an oil. ¹H NMR (CDCl₃, 400 MHz) δ 1.18 and 1.20 (2s, 9H); 1.42 and 1.44 (2s, 9H); 3.27 and 3.35 (2dd, *J* = 8.4 and 8.4 Hz, 1H); 3.69 and 3.70 (2s, 3H); 4.09 (bs, 2H); 4.79-4.85 (m, 2H); 5.22 (d, *J* = 14.6 and 3.2 Hz, 1H); 5.35 (bs, 1H); 7.25 -7.36 (m, 5H);

7.45 and 7.71 (2bs, 1H). ^{13}C NMR (CDCl_3 , 400 MHz) δ 27.2 (q); 28.2 (q); 52.4 (q); 58.2 and 58.4 (2d); 61.5 and 61.6 (2t); 73.6 and 73.8 (2d); 74.1 (d); 125.8 and 125.9 (2d); 128.2 and 128.3 (2d); 139.5 and 139.7 (2s); 170.5 and 170.6 (2s); 170.8 and 171.1 (2s). MS (CI) m/z 438 ($M+1$, 100), 383 (17). HRMS m/z calcd. for $\text{C}_{22}\text{H}_{34}\text{N}_2\text{NaO}_7$ ($M+\text{Na}$) 461.2258, found 461.2251.

Methyl 2'-(2-*tert*-butoxy-1-*tert*-butoxycarbonylaminoethyl)-[2,4']bis-oxazolyl-4-carboxylate (7).

Starting from **4** (37.7 mg, 0.084 mmol) following the general procedure using DAST, K_2CO_3 for cyclodehydration and DBU- CCl_4 for oxidation gave a crude which was purified by column chromatography on silica gel. Elution with hexane/EtOAc (3:1) gave **7** (19.8 mg, 57 %) as a white solid, m.p. 170-172 °C. ^1H NMR (CDCl_3 , 400 MHz) δ 1.1 (s, 9H); 1.46 (s, 9H); 3.69 (dd, $J = 9.2$ and 4.4 Hz, 1H); 3.82-3.88 (m, 1H); 3.94 (s, 3H); 5.02-5.09 (m, 1H); 5.5 (bd, 1H); 8.29 (s, 1H), 8.31 (s, 1H). ^{13}C NMR (CDCl_3 , 400 MHz) δ 27.2 (q); 28.2 (q); 50.0 (d); 52.2 (q); 62.8 (t), 73.7 (s); 80.1 (s); 129.7 (s); 134.2 (s); 139.5 (d); 143.6 (d); 155.2 (s); 155.7 (s); 161.3 (s); 164.5 (s). MS (FAB) m/z 410 ($M+1$, 7), 309 (19), 231 (89). HRMS m/z calcd. for $\text{C}_{19}\text{H}_{28}\text{N}_3\text{O}_7$ 410.1927, found 410.1930.

2'-(2-*tert*-Butoxy-1-*tert*-butoxycarbonylaminoethyl)-[2,4']bis-oxazolyl-4-carboxamide (8). A

solution of **7** (154 mg, 0.38 mmol) in 32% NH_4OH (12.3 mL) and MeOH (2 mL), was maintained for 5 min in the ultrasound bath and after that was stirred at room temperature for 17 h. Elimination of the solvents at vacuum afforded a quantitative yield of **8** (149 mg). ^1H NMR (CDCl_3 , 400 MHz) δ 1.09 (s, 9H); 1.44 (s, 9H); 3.70-3.73 (m, 1H); 3.81-3.84 (m, 1H); 5.06 (bs, 1H); 5.59 (bd, 1H); 5.90 (bs, 1H); 6.98 (bs, 1H); 8.18 (s, 1H); 8.25 (s, 1H). ^{13}C NMR (CDCl_3 , 400 MHz) δ 27.2 (q); 28.2 (q); 50.0 (d); 62.8 (t); 71.2 (s); 73.1 (s); 80.2 (s); 129.8 (s); 136.8 (s); 139.2 (d); 144.5 (d); 154.9 (s); 162.4 (s); 164.9 (s). MS (ES) m/z 396 ($M + 2$, 25), 339 (45), 283 (100). HRMS m/z calcd. for $\text{C}_{18}\text{H}_{26}\text{N}_4\text{NaO}_6$ ($M+\text{Na}$) 417.1745, found 417.1748.

Methyl 2-(2-*tert*-butoxy-1-*tert*-butoxycarbonylamino-ethyl)-5-phenyloxazole-4-carboxylate (9).

Compound **5** (3.8 g, 8.6 mmol) was cyclized using the general procedure with DAST[~]Pyr and DBU[~]CCl₄ for the oxidation. The reaction crude was purified by column chromatography on silica gel, elution with hexane/EtOAc (3:1) gave **9** (1.8 g, 50%) as an oil. ¹H NMR (CDCl₃, 400 MHz) δ 1.11 (s, 9H); 1.46 (s, 9H); 3.72 (dd, *J* = 9.3 and 4.3 Hz, 1H); 3.85-3.88 (m, 1H); 3.92 (s, 3H); 5.06-5.08 (m, 1H); 5.60 (bd, 1H); 7.43-7.49 (m, 3H); 8.02-8.04 (m, 2H). ¹³C NMR (CDCl₃, 400 MHz) δ 27.3 (q); 28.3 (q); 50.0 (d); 52.2 (q); 62.9 (t); 73.7 (s); 80.1 (s); 126.7 (s); 126.9 (s); 128.3 (d); 130.2 (d); 155.3 (s); 155.5 (s); 161.4 (s); 162.5 (s). MS (FAB) *m/z* 419 (M+1, 100), 363 (44), 307 (97), 275 (20). HRMS *m/z* calcd. for C₂₂H₃₁N₂O₆ 419.2182, found 419.2189.

Methyl 2-[1-(3-bromo-2,2-dimethoxy-propionylamino)-2-hydroxy-ethyl]-5-phenyl-oxazole-4-carboxylate (11). Deprotection of **9** (138 mg, 0.33 mmol) with 95% TFA and reaction with bromopiruvic acid dimethyl acetal (74 mg, 0.35 mmol) following the general procedure for peptide preparation gave a residue which was purified by column chromatography on silica gel. Elution with CH₂Cl₂/MeOH (99:1) give **11** as a yellow oil (74.5 mg, 50%). ¹H NMR (CDCl₃, 400 MHz) δ 3.29 and 3.30 (2s, 3H); 3.32 and 3.33 (2s, 3H); 3.61-3.66 (m, 2H); 3.79 and 3.88 (2s, 3H); 3.99-4.15 (m, 2H); 4.24-4.34 (m, 2H); 5.40-5.48 (m, 2H); 7.42-7.51 (m, 3H); 7.8 (bd, 1H); 7.93-8.01 (m, 2H). ¹³C NMR (CDCl₃, 400 MHz) δ 29.9 (t); 48.9 and 49.8 (2d); 49.9 and 50.6 (2q); 52.3 (q); 62.8 and 63.1 (2t); 100.4 (s); 125.9 and 126.0 (2s); 126.3 (s); 128.4 (d); 128.5 (d); 130.6 (s); 156.0 and 156.2 (2s); 158.9 (s); 161.7 and 162.1 (2s); 167.3 (s). MS (ES) *m/z* 459 (MBr⁸¹, 88), 457 (MBr⁷⁹, 83), 425 (MBr⁷⁹, 7), 427 (MBr⁸¹, 10), 359 (100). HRMS *m/z* calcd for C₁₈H₂₁BrN₂NaO₇ 479.04, found 479.04.

Methyl 2-(2-([2'-(2-bromo-1,1-dimethoxyethyl)-5-phenyl-[2,4']bisoxazolyl-4-carbonyl]-amino)-3-methylbutyrylamino)-3-methylpentanoate (12). Deprotection of **1** (1.26 g, 3.67 mmol) with 40%

TFA and reaction with the acid from saponification of **3** (1.55 g, 3.5 mmol) following the general procedure for peptide preparation gave **12** (2.08 g, 92%) as a yellow solid. This compound was used without purification in the next synthetic step. An analytical sample was purified by column chromatography. Elution with hexane/EtAcO (4:1) gave **12** as a yellow solid, m.p. 85-87 °C. ¹H NMR (CDCl₃, 400 MHz) δ 0.86 (d, *J* = 6.8 Hz, 3H); 0.91-0.97 (m, 6H); 1.00 (d, *J* = 6.4 Hz, 3H); 1.18-1.28 (m, 1H); 1.47-1.59 (m, 1H); 2.05-2.20 (m, 2H); 3.34 (s, 6H); 3.66 (s, 3H); 3.87 (s, 2H); 4.53 (dd, *J* = 8.4 and 4.8 Hz, 1H); 4.63 (dd, *J* = 8.6 and 5.8 Hz, 1H); 6.59 (d, *J* = 8.0 Hz, 1H); 7.37-7.47 (m, 3H); 7.76 (d, *J* = 8.0 Hz, 1H); 8.30 (d, *J* = 8.0 Hz, 2H); 8.36 (s, 1H). ¹³C NMR (CDCl₃, 400 MHz) δ 11.5 (q); 14.6 (q); 17.7 (q); 18.9 (q); 26.2 (t); 31.1 (d); 31.6 (t); 37.1 (d); 50.2 (q); 52.0 (q); 57.0 (d); 57.1 (d); 99.5 (s); 126.9 (s); 128.2 (d); 128.4 (d); 129.5 (s); 130.1 (d); 130.2 (s); 140.0 (d); 151.6 (s); 152.9 (s); 161.1 (s); 161.3 (s); 170.9 (s); 171.9 (s). MS (MALDI-TOF) *m/z* 673 (MBr⁸¹+Na, 100), 671 (MBr⁷⁹+Na, 100), 651 (MBr⁸¹, 10), 649 (MBr⁷⁹, 10). HRMS *m/z* calcd. for C₂₉H₃₈BrN₄O₈ 649.1868, found 649.1868.

Peptide-heterocycle 13. The general procedure for amide formation between the free acid-**12** (2.03 g, 3.2 mmol) and the *N*-deprotected-**2** (1.04 g, 3.36 mmol) gave after 20 h **13** (2.8 g, 94%) as an oil. This compound was used without purification in the following synthetic step. An analytical sample was purified by column chromatography, elution with hexane-EtAcO from 8:2 to 4:6 gave **13** as a yellow oil. ¹H NMR (CDCl₃, 400 MHz) δ 0.81-1.05 (m, 12H); 1.07 (s, 9H); 1.20 (bs, 1H); 1.44-1.62 (m, 1H); 2.06-2.17 (m, 1H); 2.19-2.31 (m, 1H); 3.37 (s, 6H); 3.66-3.76 (m, 1H); 3.77-3.84 (m, 1H); 3.90 (s, 2H); 4.40-4.54 (m, 1H); 4.56-4.68 (m, 1H); 5.30-5.45 (m, 1H); 6.70-6.85 (m, 1H); 7.27-7.33 (m, 1H); 7.38-7.50 (m, 3H); 7.76-7.84 (m, 1H); 8.01-8.58 (m, 7H). ¹³C NMR (CDCl₃, 400 MHz) δ 11.8 (q); 15.0 (q); 17.9 (q); 19.6 (q); 26.5 (t); 27.5 (q); 31.1 (d); 31.9 (t); 37.5 (d); 48.8 (d); 50.5 (q); 57.7 (d); 58.6 (d); 62.6 (t); 74.2 (s); 99.5 (s); 126.7 (s); 126.8 (s); 128.5 (d); 128.7 (d); 129.8 (s); 130.5 (d); 139.7 (d); 139.9 (s); 140.3 (d); 143.6 (d); 151.9 (s); 153.2 (s); 154.9 (s); 161.5 (s); 161.6 (s); 164.4 (s); 164.5 (s); 171.2 (s);

171.5 (s); 188.3 (s). MS (MALDI-TOF) m/z 949 (MBr⁷⁹+Na, 100), 951 (MBr⁸¹+Na 100). HRMS m/z calcd. for C₄₁H₅₂BrN₈O₁₀S 927.2705, found 927.2705.

IB-01211. A solution of **13** (2.37 g, 2.7 mmol) in 98% HCO₂H (76 ml) was refluxed during 1 h. The cool reaction mixture was poured into a solution of NaHCO₃ and extrated with CH₂Cl₂, dried, and concentrated under reduced pressure to give the keto- and *O*-deprotected **13** as a yellow oil (2.4 g, 94 %). A solution of the oil in CH₂Cl₂ (200 mL) with NaHCO₃ (0.725 g, 8.64 mmol) was stirred at room temperature for 8 h. The mixture was filtrated over alumina and washed with CH₂Cl₂/MeOH (4/1). The organic solution was concentrated to give a crude material which was dissolved in dry THF (100 mL) and was cooled at -10 °C. Lutidine (3.14 mL, 27 mmol) and TFAA (1.91 mL, 13.5 mmol) were added to the cold solution and the reaction mixture was stirred at room temperature overnight. Concentration *in vacuo* gave a brown residue, which was purified by chromatography on silica gel. Elution with CH₂Cl₂/MeOH (9:1) gave **IB01211** (210 mg, 11%) as a white solid, m.p. (MeCN) 235-236 °C (m.p. of natural product 236-238 °C; mixed m.p. 235-236 °C). $[\alpha]_D +73.2$ ($c = 0.014$, CHCl₃: MeOH, 1:1). Simultaneous injection of natural and synthetic compounds gave only one pick at $rt = 14.2$ min using a gradient of H₂O (0.045% TFA) and MeCN (0.036% TFA) starting with 0% until 100% of MeCN in 15 min. ¹H NMR (CDCl₃, 400 MHz) δ 0.87-1.05 (m, 12H); 1.16-1.29 (m, 1H); 1.37-1.50 (m, 1H); 2.14-2.30 (m, 2H); 4.01-4.15 (m, 1H); 4.94-5.03 (m, 1H); 5.87 (s, 1H); 6.51 (s, 1H); 7.41-7.59 (m, 4H); 7.91 (s, 1H); 8.16 (s, 1H); 8.20 (s, 1H); 8.27 (s, 1H); 8.28 (bs, 1H); 8.41-8.47 (m, 3H). ¹³C NMR (CDCl₃, 400 MHz) δ 11.6 (q); 14.6 (q); 19.2 (q); 19.7 (q); 26.4 (t); 30.0 (d); 37.6 (d); 57.3 (d); 63.3 (d); 106.7 (t); 118.9 (d); 126.5 (s); 127.4 (s); 128.0 (d); 128.5 (d); 129.6 (s); 130.0 (s); 130.3 (d); 136.1 (s); 136.7 (d); 137.3 (d); 138.9 (d); 141.8 (s); 151.7 (s); 153.3 (s); 155.8 (s); 157.5 (s); 158.3 (s); 159.6 (s); 160.9 (s); 171.1 (s); 172.9 (s).

¹H-NMR spectra of synthesized compounds

¹³C-NMR of synthesized compounds